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Guide to Identification of Bearing Tree Remains





Decayed Wood Identification
of
Bearing Trees of Public Land Surveys
by
Richard Drahn - Land Surveyor
Ottawa National Forest - Michigan
and
Milo Stefan - Land Surveyor
Nicolet National Forest - Wisconsin
1981

EASTERN REGION
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U. S. DEPARTMENT OF AGRICULTURE

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PREFACE

The rectangular public land surveys in the Lake States were completed before the turn of the century. Today, the bearing trees used in these surveys are generally found as stump remains in various stages of decay. The recovery and identification of these bearing-tree remains is a key link in the recovery and restoration of the corner positions established by the original Government survey.

Positive identification of tree species is changing from macroscopic to microscopic examination; the use of a hand lens to make comparisons with known wood specimens. A means of onsite comparison is the use of colored prints of cross-section slides of wood of known species in the area being resurveyed. Such colored prints of green and decayed wood are provided in this field handbook and are supplemented by a cellular structure key for aid in identification.

We are grateful to the North Central Forest Experiment Station in St. Paul, Minnesota, and the Forest Science Laboratory at Rhinelander, Wisconsin, where the wood specimens were prepared for microscope photography.



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INTRODUCTION

By definition, dendrology is that part of botany relating to trees and tree identification. The identification of tree species ranges from observation of the external characteristics of the living tree to examination of the microscopic cellular identifiers. The use of microscopic identification is limited, however, by advanced stages of decay.

Initial observation of a decayed stump and knowledge of the species and tree growth under a variety of site conditions may be all that is needed for positive identification by the experienced observer. When additional proof is needed, exposing or removing the least decayed wood from the stump, examining it under a hand lens, and comparing it with corresponding color prints of sound wood, using the cellular structure key, should enable the observer to identify the species.

Most of the species depicted in the color prints and included in the cellular structure key are native to the northern Lake States and were used as bearing trees in the original rectangular public land surveys. Color prints of other unkeyed species, which are native to the southern Lake States or other adjacent areas, are included in the Appendix.



DEFINITIONS

Annual growth ring - The total increase in a tree's diameter laid down in one season. Viewed in cross section, the growth ring is a series of concentric rings, each containing spring and summerwood.

Bark - The exterior portion of a tree consisting of corky, fibrous tissue that covers and protects the growing portion of the wood lying beneath its surface.

Conifer - Used synonymously with softwood in this text.

Cross section - A reference cut of wood tissue taken at right angles to the trunk, characterized by an end view of vessels or tracheids, and growth rings.

Hardwood - A generalization used to describe the deciduous broadleaf trees, such as the oaks, maples, birches, etc., whose wood contains vessels.

Micron - A unit of measurement equal to one-thousandth (0.001) of a millimeter.

Parenchyma cells - The small, thin-walled, secondary vessels lying in thin lines generally parallel to growth rings. These are key identifiers in the elms.

Platelets - The individual, separable layers of tree bark. Size, color, and texture of platelets are occasionally prime identifiers.

Radial section - A reference cut of wood tissue taken from the outside edge of the tree to the center, characterized by a side view of vessels or tracheids, and growth rings.

Ray - A series of small cells arranged so as to appear in a thin line formed at right angles to the growth ring. Size, arrangement, and spacing of the rays aid in wood identification.

Resin ducts - The small ducts or channels found in some conifers and visible in cross sections as whitish or bluish specks. They are also visible in radial and tangential sections.

Softwood - A generalization used to describe the conifers, such as the pines, spruces, tamaracks, etc., whose wood does not contain vessels.

Springwood - That part of the annual growth ring laid down earlier in the growing season. Generally less dense than the summerwood.

Summerwood - That part of the annual growth ring laid down later in the growing season. Generally more dense than the springwood.

Tangential section - A reference cut of wood tissue taken parallel with bark and growth rings, characterized by a side view of vessels or tracheids, and rays. It does not cross growth rings.



Tracheids - As used in this text, the elongated cells that constitute the greater part of the structure of softwoods.

Tylosis - A fine, membranous occlusion in vessels of hardwoods (particularly white oak) that often appears, under low magnification, to completely block the major vessels. It is a prime identifier in differentiating between white and red oak.

Vessels - As used in this text, the small, tubelike openings in cross sections of hardwoods, visible with 10X magnification. Size and arrangement of these vessels aid in wood identification.

Vessels - diffuse porous - The arrangement of hardwood vessels characterized by vessels of similar size uniformly dispersed throughout the spring and summerwood.

Vessels - radially porous - The arrangement of hardwood vessels characterized by an alignment of the vessels across the growth ring rather than parallel to it.

Vessels - ring porous - The arrangement of hardwood vessels characterized by a series of very large vessels laid down in the springwood. Summerwood vessels are usually considerably smaller and dispersed.

Vessels - semi-ring porous - The arrangement of hardwood vessels characterized by a gradual decrease in the size and number of vessels across the growth ring.



CELLULAR STRUCTURE KEY

A key to wood identification is the distinguishable cellular features found in each of the tree species. The presence of vessels, ducts, and rays of various sizes and locations, along with cellular variations, provides a means for species identification. As the wood decays due to moisture changes, soil conditions, and the spread of fungi, cellular structure features are altered. It is important to expose or extract the least decayed part of the tree stump to examine key identifiers.

To obtain a sample from a tree stump, make a cross-sectional cut using a sharp razor blade or knife or, if possible, break off a piece of stump by hand. A sharp cut or a broken sample will result in the least disturbed and best end view of the wood cells and vessels. The sample should be examined under a 10X or better hand lens and under a 7X or better comparator to determine the size of the vessels.

The cellular structure key is designed so the user can follow paragraph numbers found at the beginning of each paragraph through paragraph continuation referrals found at the end of each subparagraph clause until the proper species is determined. The narrative description and colored prints of cross sections for each species are referenced by page number to help confirm the identification.

The use of the key is demonstrated in the following example. Beginning at Paragraph No. 1, the user notes the wood sample has vessels present. Paragraph No. 1a describes this condition as "Hardwoods," and guides the user to Paragraph No. 2. Under Paragraph No. 2, the user notes the wood sample has vessels ring porous, which corresponds to Paragraph No. 2a. Paragraph No. 2a narrows down the possibilities to ash, elm, or oak, and directs the user to Paragraph No. 3. Under Paragraph No. 3, the user notes the wood sample has large vessels with predominant, broad rays easily visible, which corresponds to Paragraph No. 3a. Paragraph No. 3a identifies the sample as oak, and directs the user to Paragraph No. 4. Under Paragraph No. 4, the user notes the wood sample has open springwood vessels, and distinct, thick-walled, aligned, and rounded summerwood vessels, which corresponds to Paragraph No. 4a. Paragraph No. 4a identifies the species as Northern Red Oak, and directs the user to P. 26 for a narrative description and cross-section colored prints for this species to confirm proper identification.



KEY

Paragraphs 2 through 15 - Hardwoods

Paragraphs 16 through 20 - Conifers

1. a. Vessels present - Hardwoods - 2
b. Vessels absent - Conifers - 16
2. a. Vessels ring porous
Abrupt changes from springwood to summerwood - ash, elm, oak - 3
b. Vessels semi-ring porous
Springwood vessels decrease in size and frequency from spring to summerwood - butternut, cherry, walnut - 14
c. Vessels diffuse porous
American beech, aspen, basswood, birch, maple - 8
d. Vessels radially porous
American hornbeam (blue-beech), eastern hophornbeam (ironwood) - 13
3. a. Vessels large at 200 to 430 microns
Predominant, broad rays easily visible - oak - 4
b. Vessels 150 to 290 microns
Rays visible at 10X power - ash, elm - 5
4. a. Springwood vessels open. Summerwood vessels distinct, thick walled, aligned, and rounded. Northern Red Oak (Page 26)
b. Springwood vessels occluded with tylosis. Summerwood vessels thin walled, indistinct, irregularly shaped, and not well aligned. White Oak (Page 27)
5. a. Single row of vessels - elm - 6
b. Two to four rows of vessels - ash - 7
6. a. Prominent, well-defined, and wavy bands of parenchyma cells in summerwood visible without hand lens. American Elm (Page 20)
b. Parenchyma cells visible with hand lens. Cells arranged in interrupted, shallow, undulating line. Red Elm (Page 21)



7. a. Numerous small and often paired vessels in summerwood. White Ash (Page 12)
- b. Relatively few vessels seldom paired in summerwood. Black Ash (Page 11)
8. a. Narrow and very wide rays. Larger rays three to five times wider than vessels. American Beech (Page 15)
- b. Narrow rays. Rays rarely twice as wide as vessels - aspen, basswood, birch, maple - 9
9. a. Vessels randomly paired - maple - 10
- b. Vessels often paired or grouped - aspen, birch, basswood - 11
10. a. Rays prominent, of two distinct widths, and contrastingly light compared to surrounding wood. Large rays barely visible to the eye. Small rays visible at 2X to 4X. In light-colored decayed wood, vessel edges often stained light brown. Sugar Maple (Page 25)
- b. Rays of random widths are irregular and obscure. Visible with hand lens. Decayed wood vessels unstained. Red Maple (Page 24)
11. a. Rays barely visible at 10X to 20X. Rays extend over many growth rings. Aspen (Page 13)
- b. Rays visible at 10X. Rays appear contrasting, distinct, and continuous across many growth rings - basswood, birch - 12
12. a. Growth rings not distinct. Transition from spring to summerwood not noticeable. White Birch (Page 16)
- b. Growth rings show slight change from spring to summerwood. Often a faint, continuous, reddish-brown line between annual rings. Summerwood is 20 to 30 percent of annual ring width. Great variation between growing sites. Yellow Birch (Page 17)
- c. Growth rings faint to noticeable, with a gradual color transition from spring to summerwood. Single, uniform, and unbroken band of cells at start of spring growth. Cells marginally visible at 10X and distinctly visible at 20X. Summerwood may be 30 to 60 percent of annual growth width. Basswood (Page 14)
13. a. Vessels sparse and elongated, combined in pairs or short columns at right angles to growth ring. Thin cell wall between pairs or groups. Rays small and indistinct. Eastern Hophornbeam (Ironwood) (Page 22)
- b. Vessels thick walled, rounded, and profuse, decreasing slightly in number and nearly as wide as vessels. American Hornbeam (Blue-beech) (Page 23)



14. a. Wood typically semi-ring porous, generally with abrupt changes in vessel size and density at transition of springwood to summerwood. Largest vessels 60 to 100 microns narrower than largest rays. Black Cherry (Page 19)
- b. Wood marginally semi-ring porous without distinct transition from spring to summerwood. Most vessels considerably larger than rays - butternut, walnut - 15
15. a. Growth rings distinct. Rays relatively straight and continuous across many growth rings. Vessels well rounded, and infrequently elongated or multichambered. Butternut (Page 18)
- b. Growth rings indistinct to obscured, with wavy rays not appearing continuous across many growth rings. Majority of vessels appear slightly elongated with frequent double or multichambered, very elongated vessels. Black Walnut (Page 28)
16. a. Resin ducts absent - balsam, cedar, hemlock - 17
- b. Resin ducts sparse - spruce, tamarack - 19
- c. Resin ducts common, appearing as white to blue-gray spots in cross section. Appear as flecks or streaks in radial or tangential section - pine - 20
17. a. Growth rings prominent, with a relatively abrupt and jagged transition between spring and summerwood. Start of springwood evidenced by thin line of whitish cells visible at 10X. Individual cells not discernible. Typical odor from fresh cut into advanced stages of decay. Hemlock (Page 31)
- b. Growth rings faint to more or less predominant, with a gradual change between springwood and summerwood. Growth rings become obscured with decay - balsam, cedar - 18
18. a. End of summer growth has contrastingly darker row of vessels prior to start of springwood formation. Wood structure appears crystalline under 10X magnification. Shows jagged edges if split cross grain. Has characteristic odor of cedar. Northern White Cedar (Page 29)
- b. End of summer growth may show a thin, whitish line. Lacks single layer of darker cells. Occasional pitch pockets in wood. Decays rapidly and loses cellular structure characteristics. Balsam Fir (Page 30)
19. a. Resin ducts small and sparse, often in pairs. Abrupt change from springwood to summerwood. Cross-grain rays remain well-defined with advancing decay. Horse urine odor lasts into advanced stages of decay. Tamarack (Page 37)



- b. Cross-grain rays faint and continuous. Growth rings prominent with more or less abrupt transition from spring to summerwood. Characteristic odor from firm wood. Black Spruce (Page 35)
 - c. Cross-grain rays very faint and not continuous. Transition of spring to summerwood gradual. Growth rings not as prominent as black spruce. White Spruce (Page 36)
20. a. Growth rings vary from distinct to marginal, with gradual transition between spring and summerwood. Resin ducts prominent, often paired, and randomly dispersed throughout spring and summer growth. Resin ducts appear 100 microns or larger under 7X comparator. In early decay of solid wood, resin ducts appear gray to blue-gray. Individual cells discernible across entire growth ring at 10 to 20X. A light-colored wood with noticeable turpentine odor White Pine (Page 34)
- b. Distinct growth rings have abrupt transition between straw-colored springwood and much darker summerwood. Retains marked color difference well into decay process. Majority of occasionally paired resin ducts confined to late spring and summerwood growth. Appear 100 microns or less under a 7X comparator. Individual cells visible only in summerwood at 10 to 20X. Pink to reddish-colored wood retains very strong turpentine odor well into decay process. Red Pine (Page 33)
- c. Distinct growth rings with abrupt, even-lined transition between spring and summerwood. Seldom-paired resin ducts usually visible in or near darker summerwood. Ducts noticeably smaller than 100 microns under 7X comparator. Wood has light color and turpentine odor that fades rapidly with decay. Odor remains longest in resin-laden branch knots. Jack Pine (Page 32)



BLACK ASH — *Fraxinus nigra*

1. Tree - The fibrous root system is shallow. Decay is rapid in swampy locations. The wood changes from a uniform tan and light brown to dark brown and eventually becomes a blackish-brown, stringy mass.
2. Bark - Decays rapidly causing loss of major characteristics in one to two years. Thickness of 1/4 to 3/8 inch on mature trees is scaly and loose, and wipes off as a powdery dust with slight hand pressure. When wet, decayed bark has muddy feel.
3. Wood Cellular Structure - Ring porous vessels are 160 to 260 microns in diameter and arranged in two to four rows in springwood. Summerwood has few, occasionally paired, smaller vessels.

Green



Decayed





WHITE ASH — *Fraxinus americana*

1. Tree - Decayed and windthrown trees leave stump hole 6 to 12 inches deep and 50 percent larger than tree's diameter. New growth sprouts readily from cut stumps and root mound of windthrown tree.
 - a. Decayed stump is reddish-black and mottled tan, with dryer sections black. Interior of stump tends to break into large, rectangular, reddish-brown blocks in early decay stages. Mid-stage of decay is a dark reddish-brown to reddish-black, stringy mass. Final stage of decay is nearly black and without texture, becoming slimy when saturated. Moisture in stump is high, causing rapid decay. Roots from sprouts and other vegetation penetrate stump for its moisture.
 - b. With low moisture, the decay rate is slow and the decay color is black, similar to the sugar maple. Wood remains firm in the middle and becomes flaky near the bark.
2. Bark - Resembles that of the basswood, which often occupies the same area. Bark is light to medium gray and slightly darker than that of the basswood. Platelets are rougher than the basswood's and lack the parallel, continuous pattern common to the basswood. Fissures tend to form elongated diamond patterns. Bark decays rapidly, but lasts longer near the base.
3. Wood Cellular Structure - Vessels are ring porous, varying in diameter from 150 to 260 microns in the springwood, and are two to four pores deep. In summerwood, numerous smaller vessels occur singly and in pairs. The numerous and often-paired summerwood vessels separate the white ash from the black ash, which has considerably fewer, seldom paired, summerwood vessels. Orientation of paired or grouped vessels is generally parallel to growth rings.

Green



Very decayed





QUAKING ASPEN — *Populus tremuloides*
BIG TOOTH ASPEN — *Populus grandidentata*

1. Tree - Decayed and windthrown trees leave stump hole 6 to 12 inches deep. Stump hole is occasionally ringed with small sprouts. Decay characteristics are similar in both species, but stump can show different colors.
 - a. Decayed stump forms a stringy, fibrous mass becoming light gray and cream-colored. As decay continues, portions of the inner stump may become nearly snow-white, damp to the touch, and easily penetrated with a slight touch. A blue-green stain often appears when wood is still relatively firm and portions of bark are still attached.
 - b. Decayed stump can take on a reddish-orange to reddish-tan coloration, but it is not common. Stump appears dry to powdery and fractures into 3/4 by 3/4 by 2 inch vertical blocks. As decay continues, the blocks crumble and become powdery and pasty when wet.
2. Bark - Decays slower than the wood. Bark of mature trees near base is usually mottled light to dark gray and tinged with black. It is usually 1/2 to 1 inch thick, with deep fissures and flat platelets from 1/2 to 3/4 inch wide. Advance decayed wood is often held in place by the bark.
3. Wood Cellular Structure - Vessels are diffuse porous, 50 to 100 microns in diameter, and usually in pairs or groups. Largest size and density of vessels occurs in springwood. In advanced stages of decay, the decayed wood mass provides a better means for identification than do the vessels.

Green



Decayed





BASSWOOD — *Tilia americana*

1. Tree - Rate of decay is medium. Windthrown tree leaves shallow stump hole and three to seven main root holes around perimeter. New growth sprouts from stump. Tree appearance varies with site location.
 - a. Decay occurring as black, thin, fragile plates, causing easy breakdown of the stump is most common in well-drained, upland hardwood soils where few or no sprouts grow from the stump. Inner portions of the stump are often brown, distinguishing it from the sugar maple, yellow birch, and elm. Color usually varies in each stump. Occasional patches of off-white tissue are damp to the touch and have little resistance to the touch. Advanced decay culminates in a loose pile of irregularly shaped flakes, similar to the sugar maple.
 - b. Decay on silty, poorly drained soils where numerous stump sprouts occur is a gray, fibrous, soggy mass with no definite shape. When wet, decay mass has an odor of soggy newspapers compared to the musty, damp odor of the red maple.
2. Bark - Platelets are flat, 3/8 to 5/8 inch in width, and separated by deep, narrow fissures in a parallel, regular pattern. Bark in the black decay stage will last as long or longer than the bark of the sugar maple. In the gray, fibrous type of decay, the bark holds its texture with a lighter gray color. Bark tends to curve outward and down, away from the stump.
3. Wood Cellular Structure - Vessels are diffuse porous, varying in size from 60 to 160 microns in diameter, and are occasionally randomly paired or in groups, but not to the extent of the yellow birch. Unless saturated, the vessels are usually open and not stained, differing from the sugar maple whose vessels appear clogged and often stained light brown around the edges.

Green



Decayed





AMERICAN BEECH — *Fagus grandifolia*

1. Tree - Decayed tree has fairly deep stump hole. Most trees are decayed by heartwood fungi. Windthrown trees are rare. Initial decay of tree causes a black, crispy to flaky exterior. The interior remains whitish to grayish in color. Advanced decay causes an unconnected mass of thin, brittle, black ribbons similar to the dense, broad rays characteristic of the oak. Ribbon decay pattern is similiar to that of the elm.
2. Bark - Decays rapidly, but can remain in large, blocky chunks near the base. On large trees, bark is very smooth.
3. Wood Cellular Structure - Diffuse porous wood makes growth rings marginally indistinct. Vessels are 50 to 90 microns in diameter. Tylosis is present in heartwood. Large, broad rays similar to those of the oak are easily visible. Narrow rays are more abundant than broad rays.

Green



Decayed

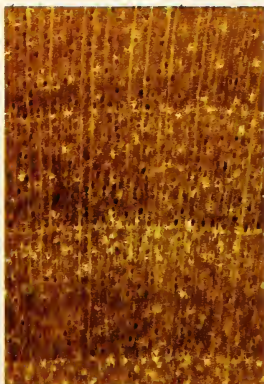




WHITE BIRCH — *Betula papyrifera*

1. Tree - This shallow-rooted tree is found in swamps and on very dry growing sites. An abundant sprouting tree, it may remain at parent tree position for many generations. Wood decays into a white, stringy mass held together by a sheath of bark. On very large specimens, decay is nearly identical to the orange, blocky, decay pattern of the yellow birch.
2. Bark - Remains persist for many years after complete decay of wood. White, curly flakes of bark are the prime identifiers.
3. Wood Cellular Structure - Diffuse porous wood makes growth rings indistinct. Vessels are 60 to 160 microns in diameter. Vessels are often paired or occasionally tripled, appearing as figure eights under a 10X hand lens. Rays are continuous, fine white lines.

Green





YELLOW BIRCH — *Betula lutea*

1. Tree - Decayed stump is shallow in areas with a high water table and one to two feet deep in well-drained soils. Wood is decay resistant. Appearance varies with site location.
 - a. A blue-green stain is often associated with the yellow birch in the black decay stage. This stain is a prime identifier, along with the presence of hoof-shaped fungi. Stump is generally brittle in this stage of decay. Inner part of stump is white to buff-colored and lacks the random, black decay lines common to the sugar maple.
 - b. Reddish-brown to orange decay occurs in moist sites. Later stages of decay turn wood to a shreddy, fibrous, orange to buff-colored mass.
2. Bark - Remains as fragments after wood fiber has completely decayed. Found as small, thin, and yellowish to buff-colored flakes or as large masses between major root folds. Large, woody bark platelets may appear similar. Prominent lenticels remain on bark until completely decayed. Thin bark, when damp, will burn with a black, greasy smoke.
3. Wood Cellular Structure - Vessels are diffuse porous and uniform in size. More than half the vessels occur in pairs or in short rows of three to four and parallel to usually indistinct annual growth rings. Paired vessels appear as figure eights under a 10X lens. Vessels are 60 to 160 microns in diameter and usually open in a dry, fresh cut of wood.

Green

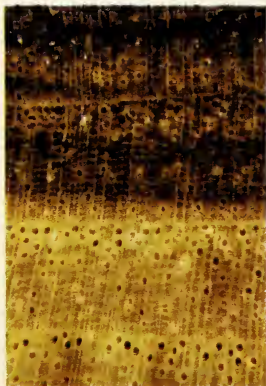




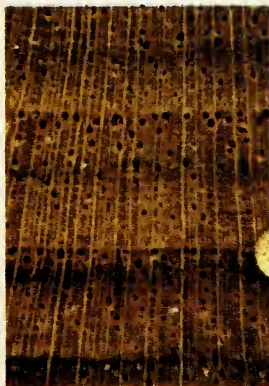
BUTTERNUT — *Juglans cinerea*

1. Tree - Decays rapidly into a dark-colored mass that disappears rapidly. Does not leave prominent stump hole.
2. Bark - Long, stringy strips decay rapidly after falling to the ground.
3. Wood Cellular Structure - Vessels are semi-ring porous and 160 to 260 microns in diameter. Rays are uniform and similar in size. Growth rings are distinct.

Green



Decayed





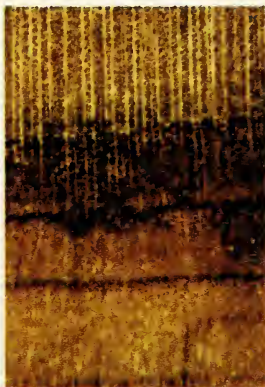
BLACK CHERRY — *Prunus serotina*

1. Tree - This upland hardwood species decays rapidly. Color of wood changes from dark red to reddish-black to yellowish-orange. Structure is initially blocky and reddish in color, then changes rapidly to a yellowish-orange, stringy mass. Final stage of decay normally consists of a leached, tannish to yellowish, unstructured mass that is powdery when dry and slimy when wet.
2. Bark - Prime identifiers are gray to black bark platelets with prominent horizontal lenticels. Bark decays rapidly except in major root folds.
3. Wood Cellular Structure - Vessels are semi-ring porous. Springwood vessels gradually decrease in size and frequency throughout growth ring. Vessels are relatively thick walled, 60 to 100 microns in diameter, and tend to occur in pairs or small groups. Cross-grain rays are numerous, continuous, and of two distinct sizes. The largest is wider than the largest vessel and the smallest is $1/4$ to $1/2$ of vessel's diameter. Rays remain conspicuous well into the decay process. Presence of black rot is a prime identifier.

Green



Decayed





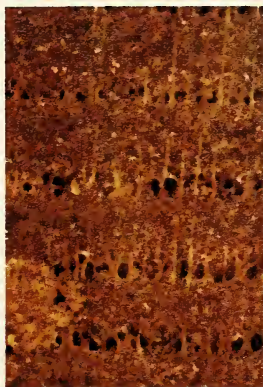
AMERICAN ELM — *Ulmus americana*

1. Tree - This moisture-seeking species is found in swamps, drainages, and heavy soils in areas with a high water table. Elms have a spreading root system and large, windthrown trees often leave a large, trench-shaped hole and earth mound. Wood is decay resistant, but in advanced stages of decay, black flakes are reduced to fragile ribbons $1/32$ by $1/8$ inch and up to 4 inches in length. Inner wood is light brown to buff-colored and occasionally gray to off-white. Decay ribbons remain to the last shred, as opposed to the sugar maple and yellow birch.
2. Bark - Platelets are generally flat-topped, with more or less diamond-shaped fissures $1/2$ to $3/4$ inch wide arranged in alternate light and dark layers. Bark attains a thickness up to $3/4$ inch from a layer of $1/16$ to $1/8$ inch platelets.
3. Wood Cellular Structure - Vessels are large and ring porous, 200 to 270 microns, and appear as a well-defined, single band. Between the ring of major vessels are numerous, wavy bands of small, thin-walled parenchyma cells barely visible to the eye. In decayed wood, these bands may appear as light-colored, wavy lines.

Green



Decayed





RED ELM — *Ulmus rubra*

1. Tree - This moisture-seeking species is found in swamps, drainages, and heavy soils in areas with a high water table. Elms have a spreading root system and large, windthrown trees often leave a large, trench-shaped hole and earth mound. Decay characteristics are the same as the American elm.
2. Bark - Characteristics are the same as the American elm, except bark thickness seldom exceeds 1/2 inch in cross section and lacks the alternate light and dark platelets. Bark has a uniform brown to reddish-brown color.
3. Wood Cellular Structure - Vessels are large and ring porous, varying in size from 200 to 290 microns. They appear as a well-defined band of cells, two to four cells deep, visible without a hand lens. The wavy bands of parenchyma cells are smaller than those of the American elm. They are arranged in shallow, undulating lines not visible without a hand lens. Unless saturated, the major vessels are open and show no evidence of discoloration.

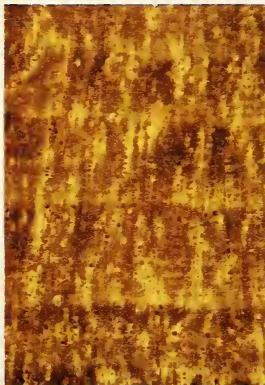
EASTERN HOPHORNBEAM (Ironwood) — *Ostrya virginiana*

1. Tree - This small tree, seldom exceeding 12 inches in diameter is found in well-drained upland sites. Surface of decaying wood is a mottled charcoal gray, black, tan, and occasionally brown. Inner wood is usually buff-colored, light tan, or yellowish-tan. As decay continues, inner wood takes on small areas of light bluish-gray. Tree usually maintains its shape until decay is well advanced and then its total structure collapses.
2. Bark - Peels in 4 to 10 inch strips curving sharply from the stem. Bark remains light gray to light brown and decays rapidly after dropping from tree trunk. Texture is slightly fibrous, less than 1/4 inch thick, and shreds easily when rubbed.
3. Wood Cellular Structure - Radially diffuse porous vessels are not uniformly distributed throughout growth ring. Vessels range in size from 60 to 100 microns and tend to pair with a thick wall between adjoining vessels. Vessels in decayed wood remain open and unstained. Down trees hold good vessel structure for a short time before developing a porous, honeycombed appearance.

Green



Decayed



AMERICAN HORNBEAM (Blue-beech) — *Carpinus caroliniana*

1. Tree - Rarely used as a bearing tree, but identification is needed to determine not so much what it is, but that it is not a bearing tree. Tree is a prolific sprouter, short lived, poorly formed, and rarely exceeds six inches in diameter. It decays rapidly where moisture content is high. Decay results in a soft, textured, gray, stringy, and loosely bound mass that separates easily.
2. Bark - Decays rapidly and appears relatively smooth and unsymmetrical, medium to dark gray.
3. Wood Cellular Structure - Diffuse porous vessels, 70 to 110 microns in diameter, and a high concentration of continuous rays produce a radially porous pattern. It is one to two vessels wide between the rays. Short, lateral decay pockets are common and tend to concentrate in summerwood.

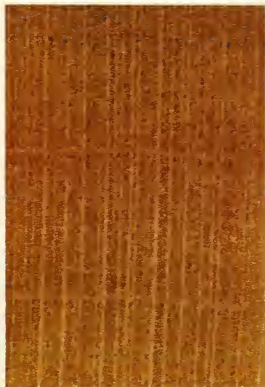
Green



RED MAPLE — *Acer rubrum*

1. Tree - Decays rapidly and sprouts from stump. Light gray to grayish-tan decay is fibrous and stringy. On wetter sites, decay is orange to reddish-orange. Decayed wood is blackish and becomes powdery when exposed to sunlight. On rare occasions, decay may be black to charcoal gray.
2. Bark - Decays rapidly and seldom outlasts wood, except possibly in the gray decay stage. Long, narrow, and flat platelets tend to curl away from the rest of the bark. Narrow fissures that are often crosshatched with cracks and minor fissures occur between major plates.
3. Wood Cellular Structure - Diffuse porous vessels, 60 to 80 microns in diameter, arranged singly or sometimes paired, are uniformly distributed throughout growth ring.

Green



Decayed



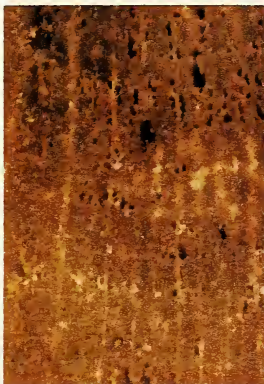
SUGAR MAPLE — *Acer saccharum*

1. Tree - Decays slowly inward from outer edge and is eventually reduced to $\frac{1}{8}$ to $\frac{1}{4}$ inch black, irregularly shaped flakes $\frac{1}{32}$ inch in thickness. Arrangement of flakes on solid stump is usually perpendicular to growth rings. Stump hole is about 50 percent larger than tree's diameter and relatively deep.
2. Bark - Has fairly fast rate of decay, especially below ground level. Remaining bark in major root folds is irregularly shaped. Platelets are uniform dark brown to gray color of varying thickness.
3. Wood Cellular Structure - Diffuse porous vessels, 70 to 90 microns in diameter, are occasionally paired. In buff-colored wood, vessels often appear filled and stained light brown around edges of vessel wall. Numerous fine rays are radially aligned from pit.

Green



Decayed





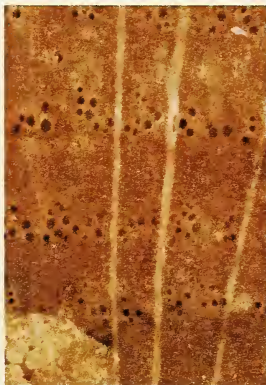
NORTHERN RED OAK — *Quercus rubra*

1. Tree - Deep taproot system leaves a deep, distinct stump hole slightly larger than diameter of stump. Tree is decay resistant and a prolific sprouter. Color characteristics are:
 - a. Dark gray to mottled brownish-black and often stained blue-green deep into firm portions of the wood. Cut stumps have tendency to erode inward from the surface leaving "rays" of extremely hard wood, 1/8 to 3/16 inch wide and 3/4 to 3 inches long, protruding from the top and/or sides of the stump.
 - b. Reddish-brown to bright orange. Drier portions of stump are dark gray to brownish-black and blue-green stained. Wood initially decays into irregularly shaped, large, blocky structures that are easily separated, and then becomes a fibrous mass with further decay. Final orange stage is powdery when dry and soggy to slimy when wet.
2. Bark - Dark brown to grayish-black, bark is 3/8 to 3/4 inch thick, and separated by shallow fissures 1/4 to 3/8 inch deep. Bark decays more rapidly than wood. Texture is woody, with a fibrous and stringy layer adjoining the wood.
3. Wood Cellular Structure - Very large, 200 to 430 micron, ring porous vessels, one to four deep, are visible without a hand lens. Springwood vessels are open, as opposed to the occluded vessels of the white oak. Occasional groups of smaller-size cells are generally arranged in short, undulating lines in summerwood at right angles to the growth rings. Summerwood vessels are thick walled, rounded, aligned, and easily visible with a hand lens, differentiating the red from the white oak.

Green



Decayed

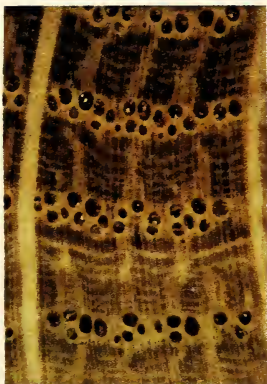




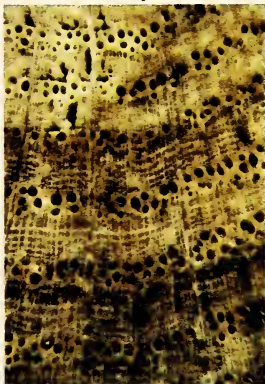
WHITE OAK — *Quercus alba*

1. Tree - This long-lived tree is very resistant to decay. Taproot is deep and leaves a deep stump hole.
2. Bark - Very resistant to decay and will remain in stump mound for years. Bark is blocky in structure and laminated with light bands.
3. Wood Cellular Structure - Ring porous wood has large springwood vessels 180 to 380 microns in diameter. Springwood vessels are occluded with tylosis, as opposed to the open vessels of the red oak. Summerwood vessels are considerably smaller, thin walled, often angular, not usually well aligned, and indistinct even with a hand lens, differentiating the white from the red oak.

Green



Decayed



BLACK WALNUT — *Juglans nigra*

1. Tree - Found in the eastern half of the United States, this large tree has dark to purplish-brown heartwood, with sapwood narrow in width.
2. Bark - Dark brown to black, bark is thick with deep furrows and narrow, forking ridges.
3. Wood Cellular Structure - Rays are smaller than largest vessels. Vessels are uniform and gradually decrease in size across annual growth rings.

Green



NORTHERN WHITE CEDAR — *Thuja occidentalis*

1. Tree - Has a shallow, widespread root system that does not leave a distinct stump hole. Tree is very decay resistant. Wood splits easily with grain and has a characteristic odor. Exterior part of stump is tan to light yellowish-brown and the inner stump is lighter tan to straw color. Cut stumps decay slowly from the inside out. The outside slowly erodes, one growth ring at a time. Final stage of decay reduces cedar to a yellowish or tan fibrous mass, tending to separate with the growth rings. A bluish stain is occasionally found on sound portions of wood. Fire-charred, blocky fragments remaining in root holes have a crystalline appearance under a 10X hand lens.
2. Bark - Decays rapidly in comparison to wood. Bark becomes a fibrous to stringy, brown mass that pulls away from wood in narrow strips. On moss-covered logs, the moss is aligned with the bark prior to its decay. The moss may be pulled away in parallel strips.
3. Wood Cellular Structure - Growth rings are distinct with light, straw-colored springwood and reddish-brown summerwood. Springwood is 75 to 90 percent of annual growth ring. Resin ducts are not present, helping to separate cedar from pine, spruce, and tamarack.

Green



Decayed





BALSAM FIR — *Abies balsamea*

1. Tree - Grows on wet and heavy soils. Has a shallow, spreading root system. Wood decays rapidly, turning from a gray to a light tan, stringy mass. With advanced decay, tissue dissolves, leaving a fibrous to stringy, unstructured, grayish mass.
2. Bark - Decays faster than wood. Pitch pockets occur in bark.
3. Wood Cellular Structure - Transition from spring to summerwood is gradual. A thin, interrupted row of cells appears as a faint, white line between the summerwood and the following year's springwood. Balsam lacks the resin ducts of pine, spruce, and tamarack.

Green



Decayed





HEMLOCK — *Tsuga canadensis*

1. Tree - Found on well-drained uplands to poorly drained swamp edges. Stump hole is slightly larger than tree's diameter and 1 to 1 1/2 feet deep. Decay-resistant wood has characteristic odor. Decay color variations include:
 - a. Orange to reddish-orange and nearby soil stained with same color. Wood structure breaks into blocky chunks parallel with and perpendicular to growth rings. Final stages of decay reduces stump to a uniform mass of bright orange, fibrous tissue easily separated with the fingers. Bark remains intact and in large plates. Rotting at ground line allows stump to slump outward.
 - b. Tan to grayish-brown decay on better drained soils. Interior portion of stump changes to brownish-yellow or yellowish-orange, fibrous mass.
2. Bark - Inner portions of bark are bright purple to cinnamon red. When saturated for long periods, bark color changes to dark brown. Platelets in cross section are approximately 1/2 to 3/4 inch wide and 1/8 inch thick.
3. Wood Cellular Structure - Growth rings are prominent, with light tan springwood and dark summerwood. Springwood is 60 to 75 percent of annual growth ring. Lacks resin ducts of pine, spruce, and tamarack.

Green



Decayed





JACK PINE — *Pinus banksiana*

1. Tree - Generally found growing on sands and gravels, but occasionally found in bogs and rock outcrops. Jack pine cones are highly resinous and decay resistant when closed. Decay on moist sites is initially a reddish to yellowish-orange, blocky structure changing to a stringy and fibrous tan or yellowish, unstructured mass. Decay on drier sites starts slowly on interior of stump and expands outward, leaving a thin, gray to tan hull of semisound wood and a rust or yellowish, stringy, unstructured, center mass.
2. Bark - Decays rather rapidly, remaining longest in major root folds. Bark is often incrustated with pitch deposits.
3. Wood Cellular Structure - Wood is very fine grained, with individual cells indistinct at 10X. Resin ducts of 75 to 90 microns in diameter appear as white flecks in cross section. They are seldom paired and tend to concentrate near or in the darker summerwood. Abrupt transition of spring to summerwood and relatively distinct growth rings remain prominent well into decay process.

Green



Decayed





RED PINE — *Pinus resinosa*

1. Tree - Primarily an upland species. With advanced stages of decay and when windthrown, tree will leave a large, shallow depression. Tree has large roots. Wood is very decay resistant due to the presence of a high concentration of pitch. Decay progresses slowly from the interior, separating wood into pinkish and rust-colored blocks that slowly disappear. Inner portion of exterior hull and exposed major roots remain a light pink to deep red. Sound wood has a heavy turpentine odor.
2. Bark - Decays rapidly where exposed, but persists in major root folds as a series of thin, orange flakes up to several inches thick. Orange flakes slowly darken to maroon and brown.
3. Wood Cellular Structure - Growth rings are distinct, with abrupt change from spring to summerwood. Majority of occasionally paired resin ducts tend to be confined to the latter half of the springwood and appear less than 100 microns under a 7X comparator. Rays are uniform, faint, and continuous across many growth rings. They become indistinct as decay progresses.

Green



Decayed





WHITE PINE — *Pinus strobus*

1. Tree - Grows under a variety of soil and moisture conditions. Large windthrown trees leave a shallow, large diameter depression. In heavy soils, complete decay leaves little evidence of stump hole. Wood is decay resistant. Sapwood is white to yellowish-white and turns tan to reddish-brown as decay progresses. A resinous odor is usually evident from freshly split samples.
2. Bark - May be several inches thick on trunks and up to six inches thick between major root folds. Bark is resistant to decay when dry, but highly susceptible to ground fires. Bark platelets are medium to dark brown, with occasional areas of brownish-orange, and usually less than 1/16 inch thick.
3. Wood Cellular Structure - Growth rings are not distinct until there is a discoloration. The springwood is usually wider than the summerwood with gradual transition. Resin ducts are common and appear as a single large cell in cross section and whitish or bluish gray-black when cut or split with the grain. Radial and vertical resin ducts remain prominent well into the decay process.

Green



Decayed





BLACK SPRUCE — *Picea mariana*

1. Tree - Pure stands are most common in deep bog sites. Tree is very shallow rooted. Wood decays rapidly when moisture content is high, but can remain for years when either dry or submerged. Wood will decay into stringy, fibrous threads and later to a purplish-black, blocky structure. Growth rings are distinct and very narrow on poor sites.
2. Bark - Consists of very thin, small, irregular scales that slough off and decay rapidly.
3. Wood Cellular Structure - Growth rings remain distinct to faint as decay progresses. Wood is made up of tracheids 25 to 30 microns in diameter. Rays are usually a single cell in width. Resin ducts are 50 to 90 microns in diameter and appear as small, white dots with 10X hand lens.

Green

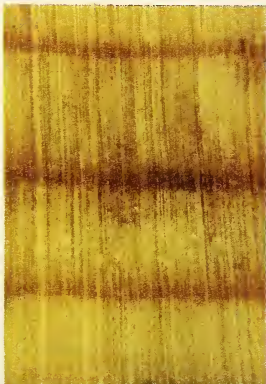




WHITE SPRUCE — *Picea glauca*

1. Tree - Found in swamps and on ridge tops. Tree is very shallow rooted. Wood decays rapidly into an orange, stringy, fibrous mass. White pocket rot is common.
2. Bark - Can be found as small platelets in root folds. Bark remains long after wood has disappeared.
3. Wood Cellular Structure - Growth rings are large on good sites. Wood is made up of tracheids 25 to 30 microns in diameter. Rays are usually single-cell wide, indistinct, and interrupted. Resin ducts are very sparse, 50 to 90 microns in diameter, and appear as small, white dots with a 10X lens. Transition of spring to summerwood is gradual, but becomes indistinct as decay progresses.

Green



Decayed





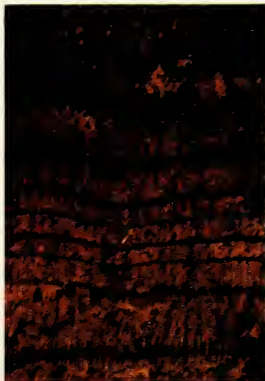
TAMARACK — *Larix laricina*

1. Tree - Found in lowlands in open areas. Stump hole is a shallow, large diameter, irregular depression. Tree has a very slow rate of decay and it is not uncommon for dead trees to remain standing for 60 to 70 years. In green wood, sapwood is whitish to light brown and heartwood is reddish-brown. On long-dead trees, the exterior retains a light to charcoal gray color, with the interior gradually separating into a brown to reddish-brown, blocky structure. External decay is very slow, one growth ring at a time. When dry, a resinous odor is present.
2. Bark - Often persists in patches on exposed portions of stump and at ground line. When dry, bark is gray to reddish-brown on the exterior and orange to reddish-brown underneath. Bark is a series of 1/2 to 3/4 inch platelets 1/16 inch thick.
3. Wood Cellular Structure - Growth rings are distinct, with the springwood tan to reddish-brown to near black, depending on the stage of decay. Springwood comprises 75 to 90 percent of cross section, with abrupt change to darker summerwood. Resin ducts located in the summerwood are occasionally paired and visible with a hand lens. Wood contains a large number of fine rays perpendicular to the growth rings.

Green



Decayed





APPENDIX

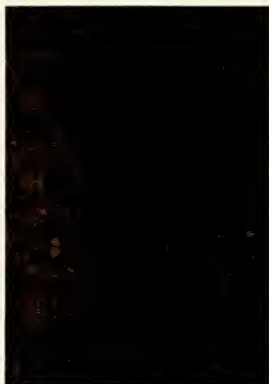
CROSS SECTIONS OF UNKEYED WOOD SPECIMENS

HICKORY — *Carya*

Green

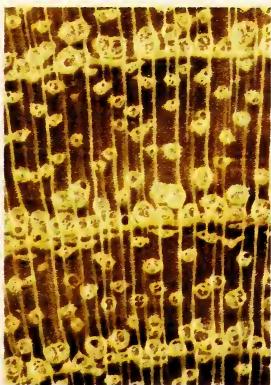


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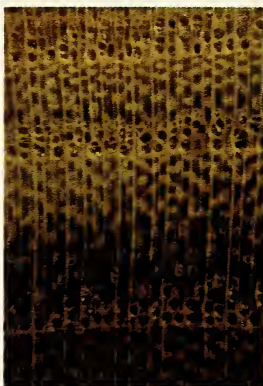
BLACK LOCUST — *Robinia pseudoacacia*

Green

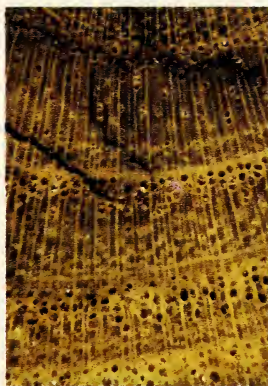


MULBERRY — *Morus*

Green



Decayed



BLACKJACK OAK — *Quercus marilandica*

Green



Decayed



CHINKAPIN OAK — *Quercus muehlenbergii*

Green



Decayed

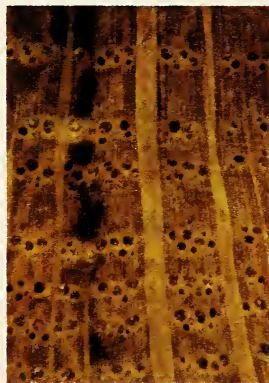


POST OAK — *Quercus stellata*

Green

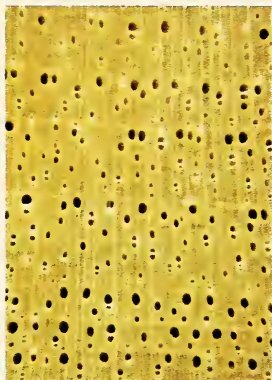


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PERSIMMON — *Diospyros virginiana*

Green



Decayed

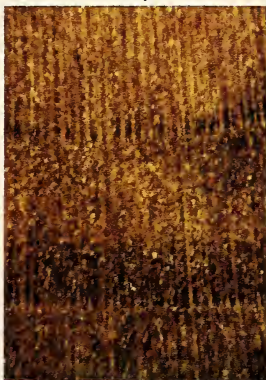


YELLOW POPLAR — *Liriodendron tulipifera*

Green

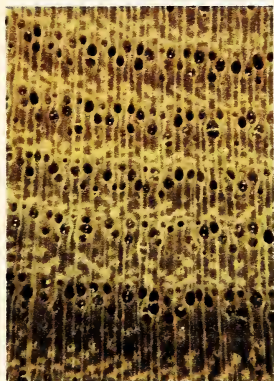


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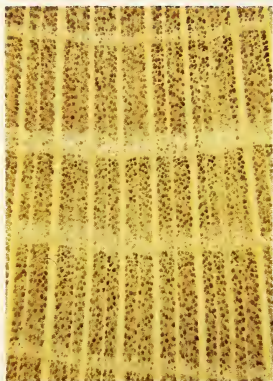
SASSAFRAS — *Sassafras albidum*

Green



SYCAMORE — *Platanus occidentalis*

Green



Decayed



EASTERN RED CEDAR — *Juniperus virginiana*

Green

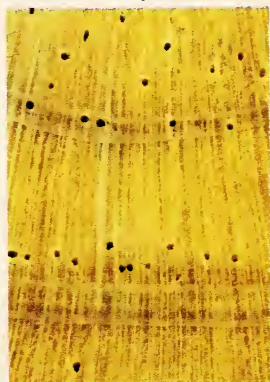


SHORTLEAF PINE — *Pinus echinata*

Green



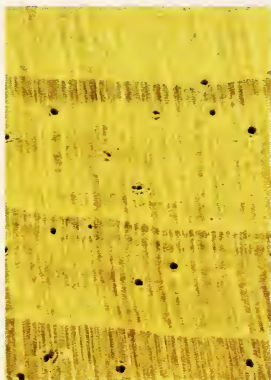
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SLASH PINE — *Pinus elliotii*

Green







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